Millipeds from late Paleozoic limestones at Hamilton, Kansas

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Abstract

Millipeds are among the more common land animals found preserved in the late Paleozoic (Pennsylvanian or Permian) limestones exposed in quarries at Hamilton, Kansas. One milliped, a euphoberiid diplopod, is known from more than 20 specimens. This milliped ranged in length to about 27 cm in life. Disarticulated portions of this euphoberiid have been found in a coprolite. An indeterminate fossil, perhaps representing a juliform diplopod, has also been found at this locality.

Introduction

Thomas E. Bridge, Gilbert A. Leisman, and Walter Lockard, of Emporia State University, Emporia, Kansas, first reported (1972) the occurrence of myriapods among a diverse faunal and floral assemblage found in the upper Paleozoic limestones at Hamilton, Kansas. Subsequently, Lockard, Bridge, Gene Mapes and Royal Mapes of Ohio University, and others have collected more than 20 probable milliped fossils from quarries at Hamilton. A number of these fossils are now deposited in collections of the Geology Department of Emporia State University (ESU), Emporia, Kansas, the collections of University of Kansas Museum of Invertebrate Paleontology (KUMIP), Lawrence, and the Hunterian Museum, Glasgow, Scotland.

Millipeds are among the more common land animals found preserved in the quarries at Hamilton. By contrast, only single specimens of a whipscorpion and a scorpion have been found in these deposits (Hanson, Bridge, and Mapes, this volume).

Myriapods from Hamilton quarry have been mentioned in a number of works, including Bridge (1977), Zidek (1976), and Johnston (1982). The myriapods were illustrated, identified as millipeds, and discussed in Hanson (1973) and Rolfe (1985). The purpose of this paper is to briefly describe, and comment on, these millipeds.

The milliped fauna

The milliped fauna consists of euphoberiid, and possibly juliform, millipeds. Euphoberiids are a group of extinct archipolypod diplopods with more than 20 and probably fewer than 60 body segments. Each segment is constructed of two fused, pleurotergal elements, the anterior portion of which is termed the prozonite and the posterior part of which is termed a metazonite (figure 1), and two ventral elements, termed sterna. Most of the body segments bear two pairs of large, prominent legs. Spines and tubercles, or both, are common features on both the dorsal and lateral surfaces. The group name is derived from the name of one of the Carboniferous forms, *Euphoberia*.

Juliform diplopods are elongate, cylindrical, helminthomorph diplopods, with between about 30 and 100 body segments. The body segments have coalesced tergites, pleurites, and sternites. The segments tend to be smooth in comparison to those of euphoberiids. This

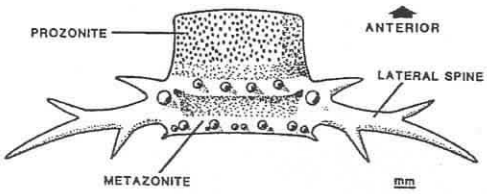

FIGURE 1—DIAGRAMATIC SKETCH OF A SINGLE MID-BODY SEGMENT OF THE EUPHOBERIID MILLIPED IN DORSAL VIEW.

informal group, which includes both extinct and extant forms, is named for the modern diplopod *Julus*.

Most of the milliped remains have been recovered from the main quarry mapped by Mapes and Rothwell (1984, figure 1; also in this guidebook). They are found on bedding planes in limonitic, yellow-brown to dark-brownish-gray, thinly laminated, and often wavy-bedded limestone. Most have been found in one limestone lentil located immediately above the conglomerate in the northern part of the quarry system in the area of the main pit (R. Mapes, personal communication, 1987). The yellow-brown color of portions of the limestone is due to finely disseminated limonite. There is very little siliceous material in the limestone matrix.

Specimens of myriapods typically are found as isolated individuals (R. Mapes, personal communication, 1987). Associated with the myriapods are plant debris, ostracodes, and fragments of indeterminate arthropods.

The euphoberiid milliped

Description—figures 2A-B, 3A-B

These are large euphoberiid diplopods, with more or less complete specimens ranging in length from 12 to more than 23 cm, and in width (including spines) from 1 to more than 5 cm. They have approximately 27 diplosegments. The head is large and bears large, aggregate eyes. Diplosegments, beginning with the third(?), and including all subsequent segments except the last, have a simple prozonite and spinous metazonite, separated by a smooth interzonal constriction. The prozonite is subequal to the metazonite in length and was probably well exposed in life. Very small, shallow, rounded pits, circular to oblong in shape, cover at least the more dorsal portions of the prozonite. The metazonite has anterior and posterior spinous, transverse, raised areas that are separated by a smooth median, depressed area. The anterior row of spines on typical midbody segments consists of four widely spaced, upright, simple spines; the posterior row consists of 12 simple spines of varying sizes. This milliped has large paranota, generally as long or longer than the legs, each composed of a large trifurcate lateral spine, an anterior spine, and a boss located just axial to the base of the anterior spine. Lateral spines of the midbody segments are normally directed laterally; those of posterior segments are directed dorsolaterally.

The terminal segment is short, with two simple, long spines directed backwards from the posterior border; these spines are sometimes gently bowed outward.

There are two pairs of broad sternites per diplosegment, with slightly thickened lateral rims.

The legs are long, about the length of the lateral spines, and smooth, except for minute punctations. A large modified leg (clasping appendage?) is located on a midbody segment of presumed male specimens.

Remarks

More than 20 specimens of this milliped, most consisting of five or more segments, have been found. Hanson (1973, p. 5-6) referred this milliped to the genus *Euphoberia* and Rolfe (1985, p. 304) referred it to the species *Acantherpestes major*. However, it represents an undescribed genus and species.

This milliped ranged in length to about 27 cm in life. It is in the same size range as, and shares a number of characters with, the euphoberiids *Euphoberia*, *Acantherpestes*, and *Myriacantherpestes*. Like these taxa, the milliped has a large head with aggregate eyes, large lateral spines, long legs, and wide sterna. The number of segments, the presence of two spinose, transverse, raised areas, and several other features serve to differentiate the new taxon from these genera, which have a pair of paramedian spines on one ridge of the metazonite. Of the described forms of fossil diplopods, this form most closely resembles the Carboniferous specimen of *Euphoberia brownii* Woodward, 1871, noted by Bolton (1905, p. 437) and described and illustrated by Woodward (1905) from the Soapstone bed near Colne, Lancashire, England. Like the Kansas form, this specimen of *E. brownii* has a simple prozonite and a metazonite with anterior and posterior raised areas. Other specimens referred to *E. brownii*, all found in Great Britain, are too poorly described or illustrated to compare here. Details of the spines and tubercles of the metazonite of the specimen of *E. brownii*, described by Woodward, however, appear to differ from those of the Kansas form. This specimen of *E. brownii* and the Kansas taxon are sufficiently different from other specimens of *Euphoberia* to refer them to a new genus.

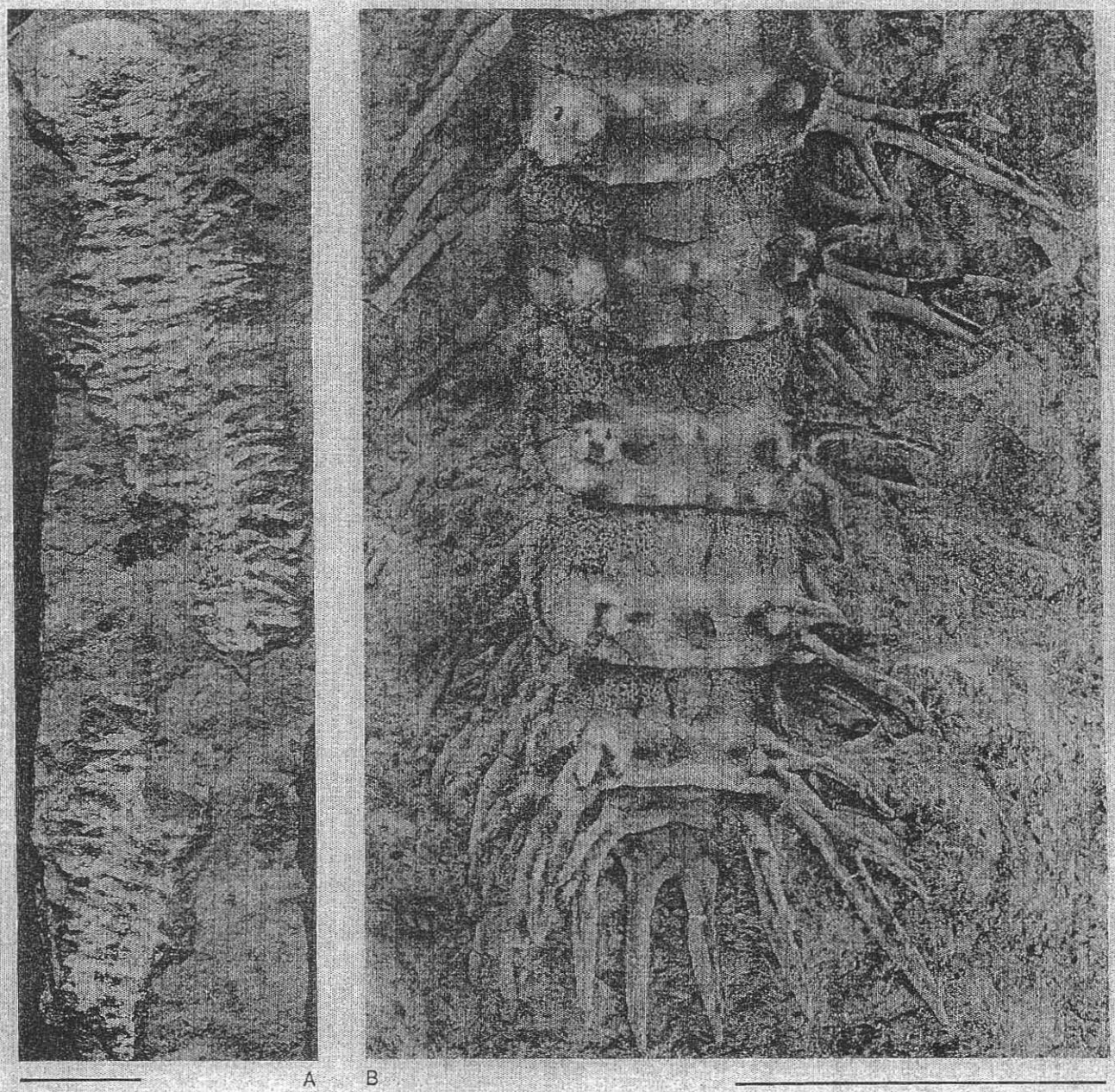

FIGURE 2—Euphoberiid millipeds. A. KUMIP 230600, unwhitened to show one typical mode of preservation; B. Latex (whitened) of the posterior of ESU HQ 294c. Scale bar = 1 cm.

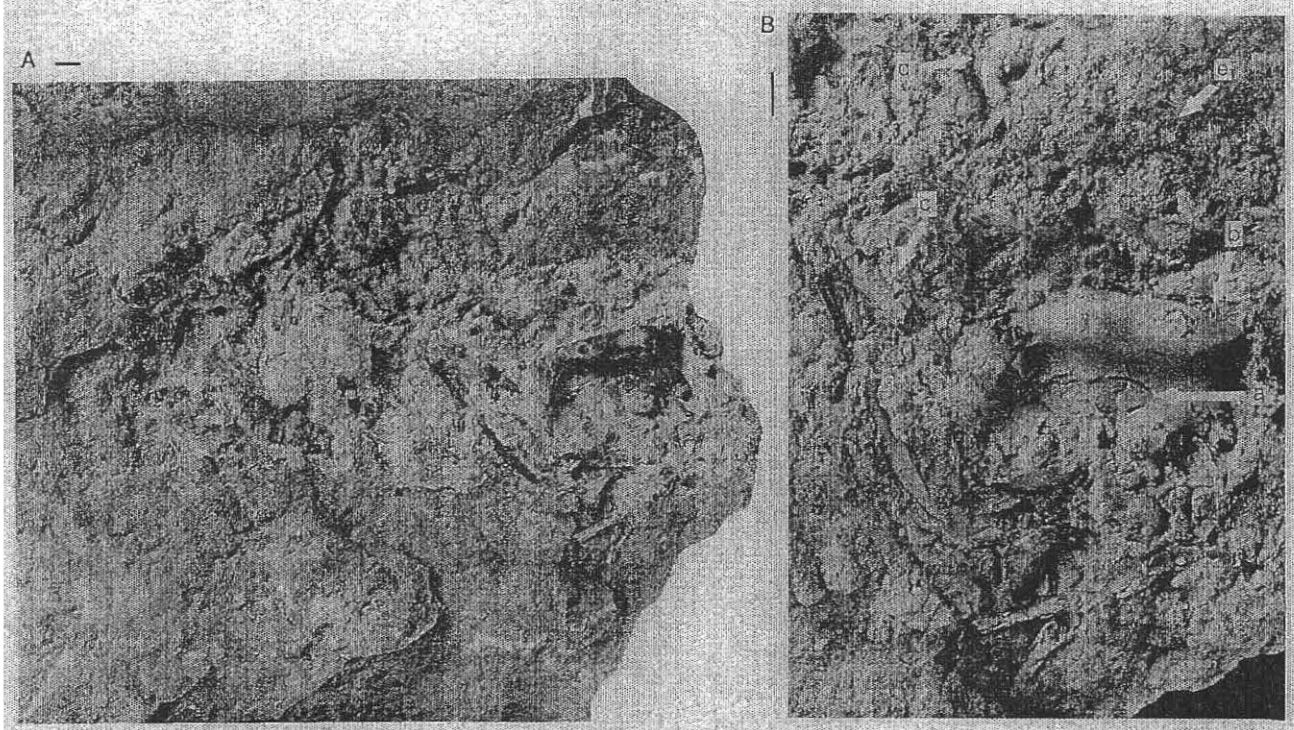

FIGURE 3—Coprolite containing euphoberiid remains, KUMIP 232999. A. View of the entire coprolite, unwhitened, to show contrast of the light-colored groundmass with the darker matrix; B. Close-up (whitened) of the coprolite, with curved grooves (a) and a round indention (b) on a metazonite of a euphoberiid and a lateral spine (c) indicated. A spirorbid worm (d) and ostracodes (e) are also indicated. Scale bar = 1 mm.

Preservation

Preservation of the dorsal side, particularly of the midsection, of the millipeds is generally good. The ventral side of the animal is rarely preserved. In some cases, the body is split open longitudinally. These may be molts, or may represent animals in the process of molting. Some of the spines are crushed, as noted by Rolfe (1985, p. 304).

Microanalysis of the material replacing the spines of one specimen (ESU HQ 294) by energy-dispersive X-rays shows it to be composed primarily of calcite. Concentrations of elements as determined by relative peak height intensities for averages of two samples are as follows: Ca, 83.8%; Si, 5.8%; P, 5.6%; Al, 4.2%; and Mg, 0.6%.

Paleoecology

Scudder (1882), Kraus (1974), Rolfe (1985), and others have pointed out that the spines of the large spiny millipeds probably served as a defensive mechanism. Rolfe (1985, p. 304) found the presence of broken and crushed spines on the Kansas millipeds to be an indication of the effectiveness of these spines in defense.

Scudder (1882, p. 145) argued that the fossil spined myriapods, since they already had a spiny armament, would not be expected to have defensive glands. Examination of a specimen of *Acantherpestes ornatus* that had been described and illustrated by Fritsch (1899, Pl. 136, figure 1) reveals rimmed circular features, located just anterior to the lateral spines, that may represent ozopores. We have not observed ozopores, however, on the Kansas form.

It is unlikely that these large-spined millipeds would have been adept at burrowing. This is indicated by the large, spined paranota, wide sterna, separate from the pleurotergites, and long legs. At least some modern open-habitat, tropical polydesmids have relatively long legs (Lewis, 1974). Despite many statements in older literature, and at least one recent statement (Lawrence, 1984, p. 131-2, 134), there is no evidence for swimming legs or gill-organs on these or any other archipolypod diplopods.

Coprolite

A coprolite (figure 3) containing remains of the euphoberiid has also been identified in the Hamilton quarry material. This coprolite, KUMIP 232999, is very

pale orange (10 YR 8/2 dry color), flattened, and oblong in shape (27 mm long by 12 mm wide, and about 2 mm thick). It was probably collected from the main quarry pit at Hamilton (R. Mapes, personal communication, 1987).

The specimen is a readily recognizable coprolite. Its general morphology and the texture and color of its light-colored groundmass, composed of phosphatic material, possibly derived from muscle mass, is typical of coprolites (Michael E. Williams, personal communication, 1988).

The coprolite contains several body segments of the milliped. One segment is represented by the dorsal portion of a metazonite. The surface of the cuticle of this metazonite is partially exfoliated, with two curved grooves that could be the result of predation. Also, there is a round indention toward its upper right that could be a tooth mark. A large portion of a lateral spine, disarticulated from a metazonite, and other, indeterminate, euphoberiid parts, are also present. Remains of several small, annulated worm tubes (spirorbids) and a large number of ostracodes are present on the margins of the coprolite, for the most part outside of the groundmass.

Reports of milliped remains in coprolites are rare. Fisher (1979, p. 436, figure 4F) reported milliped remains, associated with *Euproops*, in "coprolitic" [his quotes] concretions from Mazon Creek, Illinois. The milliped remains ranged from well preserved to disarticulated. Dawson (*in* Scudder, 1895, p. 66) reported segments of millipeds in coprolitic matter associated with bones of reptiles found at Joggins, Nova Scotia.

Several types of animals, including various amphibians, reptiles, and fish are known to consume myriapods (Cloudsley-Thompson, 1949). However, myriapods compose only small proportions of the diets of fish (Cloudsley-Thompson, 1949, p. 138; Needham, 1930, tables 3 and 7; Ricker, 1930, table 1). Amphibians are among the most voracious predators of myriapods today. Since several types of animals were large enough to produce the coprolite, and since the flattened coprolite does not have a shape that would tie it to a particular predator, the identity of the predator cannot be determined.

The juliform diplopod?

Figures 4A-B

Some poorly preserved specimens may represent myriapods. The best preserved of these, KUMIP 230601 (figure 4), may represent a juliform diplopod of indeterminate ordinal classification. This specimen is composed of calcite. It is 52 mm long, as preserved and measured along the length of the fossil. It is incomplete; regions inferred to be the posterior and portions of the midsection are missing. Although the specimen is crushed, the probable width is about 4.5 mm. There were probably more than 30 segments in life. The segments are divided into at least two sections by transverse constrictions. Thin grooves extend perpendicular to the transverse constrictions, lengthwise along the tergites.

This fossil seems to bear some resemblance in overall size, shape, and ornamentation to various cylindrical forms described by Fritsch (1899), to *Xylobius permicus* Beurlen, 1925, and some other described forms. The poor preservation of this specimen, however, makes identification difficult. The specimen is here described and illustrated only for completeness. It is tentatively assigned based upon its segmented appearance and the nature of the calcitic cuticle, which resembles that of the euphoberiids found at this locality. Conceivably, it may not be a milliped and could be referrable to "Vermes."

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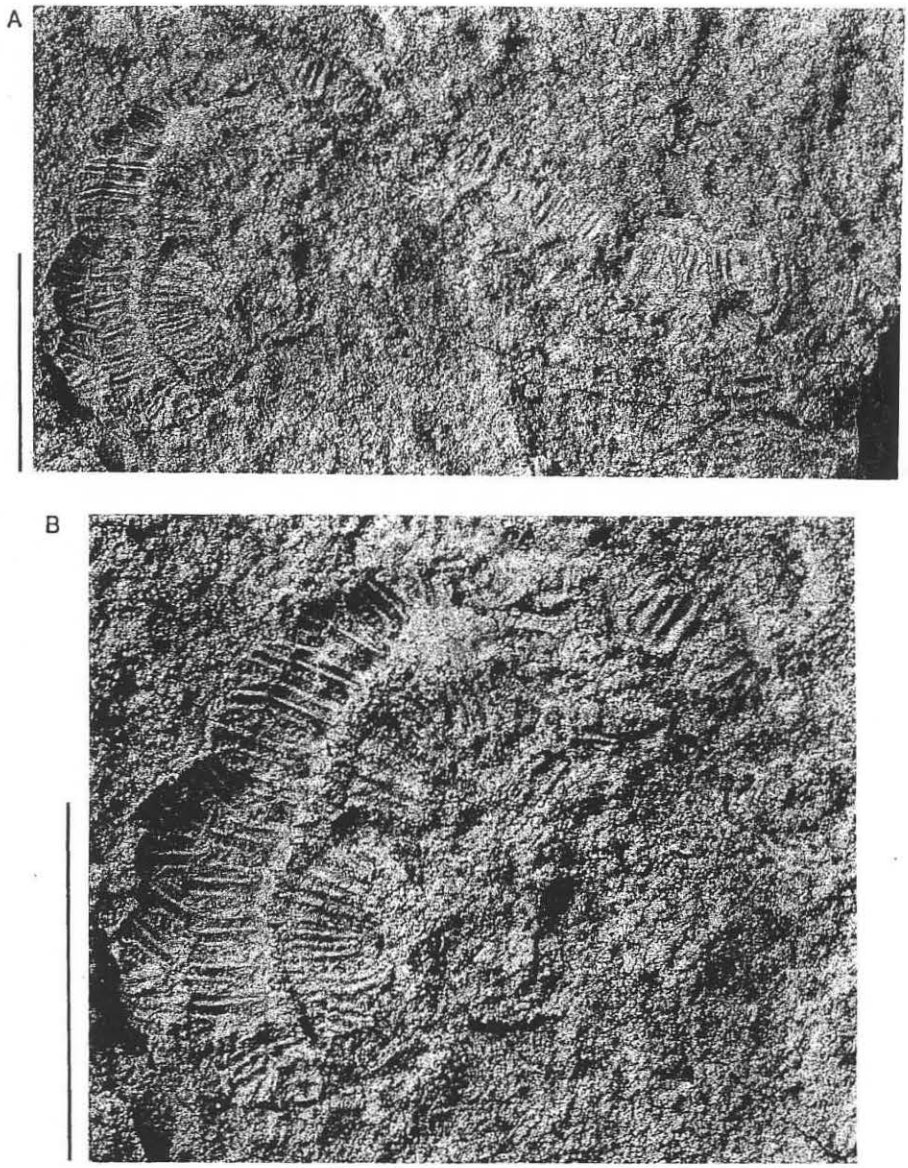

FIGURE 4—JULIFORM MILLIPED(?), KUMIP 230601; A. OVERALL VIEW; B. CLOSE-UP OF THE ANTERIOR(?) OF THE SAME SPECIMEN. SCALE BAR = 1 CM.

References

Beurlen, K., 1925, Über einen Myriapoden aus dem unteren Perm in Sachsen: Centralblatt für Mineralogie, Geologie und Paläontologie. Abteilung B: Geologie und Paläontologie, p. 182-191.

Bolton, H., 1905, Notes on the geological horizon and palaeontology of the "Soapstone bed" in the Lower Coal-Measures, near Colne, Lancashire: The Geological Magazine, New Series, Decade V, v. 2, p. 433-437.

Bridge, T. E., 1977, Fauna and flora of the Hamilton quarry channel deposits: Kansas Academy of Science, Transactions, v. 79, no. 3-4, p. 99-100.

Bridge, T. E., Leisman, G. A., and Lockard, W., 1972, Vertebrate, invertebrate, and plant fossils of the Hamilton quarry: Geological Society of America, Abstracts with Programs, v. 4, no. 4, p. 275.

Cloudsley-Thompson, J. L., 1949, The enemies of myriapods: Naturalist, p. 137-141.

Fisher, D. C., 1979, Evidence for subaerial activity of *Euproops danae* (Merostomata, Xiphosurida); *in* Mazon Creek Fossils, M. H. Nitecki, ed.: Academic Press, New York, p. 379-447.

Fritsch, A., 1899, Fauna der Gaskohle und der Kalksteine der Permformation Böhmens: v. 4, pt. 1, Prague, 152 p.

Hanson, J., 1973, Upper Pennsylvanian insect fossils from Hamilton quarry: Unpublished M.S. research paper, Kansas State Teachers College of Emporia (now Emporia State University), 26 p.

Johnston, P., 1982, Geology Museum—Emporia State University: The Kansas School Naturalist, v. 29, no. 2, p. 1-16.

Kraus, O., 1974, On the morphology of Palaeozoic diplopods: Symposium of the Zoological Society of London, no. 32, p. 13-22.

Lawrence, R. F., 1984, The centipedes and millipedes of Southern Africa—a guide: Cape Town, A. A. Balkema, 148 p.

Lewis, J. G. E., 1974, The ecology of centipedes and millipedes in northern Nigeria: Symposium of the Zoological Society of London, No. 32, p. 423-431.

Mapes, G. and G. W. Rothwell, 1984, Permineralized ovulate cones of *Lebachia* from late Palaeozoic limestones of Kansas: Palaeontology, v. 27, pt. 1, p. 69-94.

Needham, P. R., 1930, Studies on the seasonal food of brook trout: Transactions of the American Fisheries Society, v. 60, p. 73-88.

Ricker, W. E., 1930, Feeding habits of speckled trout in Ontario waters: Transactions of the American Fisheries Society, v. 60, p. 64-72.

Rolfe, W. D. I., 1985, Aspects of the Carboniferous terrestrial arthropod community; *in* Neuvième Congrès International de Stratigraphie et de Géologie du Carbonifère: Compte Rendu, v. 5, Paleontology, Paleoecology, Paleogeography, J. T. Dutro, Jr., and H. W. Pfefferkorn eds., Southern Illinois University Press, p. 303-316.

Scudder, S. H., 1882, Archipolypoda, a subordinal type of spined myriapods from the Carboniferous formation: Memoirs of the Boston Society of Natural History, v. 3, no. 5, p. 143-182.

_____, 1895, Notes upon myriapods and arachnids found in sigillarian stumps in the Nova Scotia coal field: Geological Survey of Canada, Contributions to Canadian Palaeontology, v. 2, p. 57-66.

Woodward, H., 1871, On *Euphoberia Brownii* H. Woodw., a new species of myriapod from the Coal-Measures of the west of Scotland: The Geological Magazine, New Series, Decade V, v. 8, p. 102-107.

_____, 1905, Notes on some crustaceans and two myriopods from the lower Coal-Measures near Colne, Lancashire: The Geological Magazine, New Series, Decade V, v. 2, p. 437-444.

Zidek, J., 1976, Kansas Hamilton quarry (Upper Pennsylvanian) *Acanthodes*, with remarks on the previously reported North American occurrences of the genus: University of Kansas, Paleontological Contributions, Paper 83, p. 1-41.